LANSCE
Los Alamos Neutron Science Center

Research Proposal for the use of Neutron Science Facilities

Proposal Number: 20111546
Submission Number: S1530
Date Received: 03/14/11

☐ **Fast Access** ☐ **Joint CINT Proposal**

Program Advisory Subcommittee: Other Neutron and Nuclear Science
Focus Area:

Flight Path/Instrument: Target 2 / Blue Room
Estimated Beam Time (days): 2
Days Recommended: 0
Dates Desired: Days in June/July in conjunction w
Impossible Dates:

TITLE
Spallation Production Cross Section Measurements in Hg Targets

☐ Continuation of Proposal #:
☒ Ph.D Thesis for: Dwayne Blaylock

Principal Investigator: Blaylock, Dwayne P
Institution: Georgia Institute of Technology
Citizenship: United States of America
Phone: 404-894-3606 **FAX:**
Email: dwayne.blaylock@nre.gatech.edu
Local Contact: Bitteker, Leo J

Co-Proposers	Institution	Citizenship	E-mail Address
Ferguson, Phillip D	Oak Ridge National Laboratory	United States of Am	fergusonpd@ornl.gov
Hertel, Nolan E.	Georgia Institute of Technology	United States of Am	nolan.hertel@me.gatech.edu

RESEARCH AREA

- ☐ Biological and Life Science
- ☐ Chemistry
- ☐ National Security
- ☐ Earth Sciences
- ☐ Engineering
- ☐ Environmental Sciences
- ☐ Nuc. Physics/chemistry
- ☐ Astrophysics
- ☐ Few Body Physics
- ☐ Fund. Physics
- ☐ Elec. Device Testing
- ☐ Dosimetry/Med/Bio
- ☐ Earth/Space Sciences
- ☐ Materials Properties/Test
- ☐ Other:
- ☐ Mat'l Science (incl Cond Matter)
- ☐ Medical Applications
- ☐ Nuclear Physics
- ☐ Polymers
- ☐ Physics (Excl Condensed Matter)
- ☐ Instrument Development
- ☐ Neutron Physics
- ☐ Fission
- ☐ Reactions
- ☐ Spectroscopy
- ☒ Nuc. Accel. Reactor Eng.
- ☐ Def. Science/Weapons Physics
- ☐ Radiography
- ☐ Threat Reduction/Homeland Sec.
- ☐ Other:

FUNDING AGENCY

- ☐ DOE/BES
- ☐ DOE/OBER
- ☐ DOE/NNSA
- ☐ DOE/NE
- ☐ DOE/SC
- ☒ DOE/Other SNS/ORNL
- ☐ DOD
- ☐ NSF
- ☐ Industry
- ☐ NASA
- ☐ NIH
- ☐ Foreign:
- ☐ Other US Gov't:
- ☐ Other:

PUBLICATIONS

Publications:

Eric Burgett, A Broad Spectrum Neutron Spectrometer Utilizing A High Energy Bonner Sphere Extension, M. S. Thesis, May 2008.

Rebecca M. Howell, Eric Burgett, Nolan E. Hertel, Stephen F. Kry, Zhonglu Wang and Mohammad Salehpour, Measurement of High-Energy Neutron Spectra with a Bonner Sphere Extension (BSE) System, Nuclear Technology 168, 333-339(2009).

Eric A. Burgett, Nolan E. Hertel, and Rebecca M. Howell, Energy Response and Angular Dependence of a Bonner Sphere Extension, IEEE Transactions On Nuclear Science 56, 1325-1329(2009).

Abstract: S1530_LANSCE_propo.doc

By electronic submission, the Principal Investigator certifies that this information is correct to the best of their knowledge.

Safety and Feasibility Review ***(to be completed by LANSCE Instrument Scientist/Responsible)***

☐ **No further safety review required** ☐ **To be reviewed by Experiment Safety Committee**

☐ **Approved by Experiment Safety Committee, Date:**

Recommended # of days:	**Change PAC Subcommittee and/or Focus Area to:**	**Change Instrument to:**

Comments for PAC to consider:

Instrument scientist signature: **Date:**

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Spallation Production Cross Section Measurements in Hg Targets

Mr. Dwayne Blaylock (Georgia Tech)
Dr. Nolan Hertel (Georgia Tech)
Dr. Phillip Ferguson (ORNL, Spallation Neutron Source)

Introduction

In an ongoing project a sample of mercury from the SNS taken after initial startup testing in 2006 has been analyzed via gamma spectroscopy at Georgia Tech. The measured specific activities of isotopes identified have been compared to values predicted via MCNPX and CINDER 90 codes using a model of the SNS target and shield. For some of the isotopes identified the measured versus calculated activities are well predicted (within a factor of 2), but many others are not predicted well at all. The reasons behind the differences between the measured and calculated values have yet to be determined, but they include the method in which the sample was obtained, the complexity of systems in SNS target loop, the possibility of select isotopes plating out on the stainless steel piping (type 316) in the SNS loop, and the production cross sections as modeled within MCNPX.

Therefore a benchmark experiment is being proposed to measure the production cross section of several short to medium half-life isotopes that are produced within a mercury spallation target. In the design of the experiment several isotopes of interest were selected due to their half-life. Additionally some of the isotopes selected were well predicted by calculations and others selected showed a drastic difference between measured and calculated values. Table 1 identifies the isotopes selected for the design of the experiment as well as their associated half-lives and the calculated to measured ratio from analysis of the SNS start-up mercury.

Table 1: Selected isotopes and C/M ratio

Isotope	Half-Life	Calculated / Measured Ratio
Lu 173	1.37 y	0.289
Te 121	19.4 d	0.004
Au 195	186.1 d	0.056
Ba 133	10.5 y	0.658
Os 185	53.6 d	0.632

Experiment

For this experiment, two mercury filled target assemblies will be irradiated at separate times with 800 MeV protons in the Target 2 (blue room) of the Los Alamos Neutron Science Center (LANSCE). For each irradiation the target assembly will be irradiated for a total of 750 seconds in an 80 nA beam. The cylindrical assemblies will be made of stainless steel (type 316) and filled with mercury. Using MCNPX and CINDER90 these assemblies have been modeled to predict the spallation products produced and their concentrations as they decay. Additionally a hand calculation of the temperature increase and corresponding volume increase of the mercury has been made. The specific dimensions of the assemblies and other important data are described in Table 2.

Table 2: Target Assembly Data

	Target 1	Target 2
Mercury Cavity	2.5 cm (radius) x 1.0 cm (length)	2.5 cm (radius) x 1.5 cm (length)
Mercury Volume	19.635 cm^3	29.452 cm^3
Radial Wall Thickness	0.25 cm	0.25 cm
Front Wall Thickness	0.10 cm	0.10 cm
Back Wall Thickness	0.10 cm	0.10 cm
Mercury Temperature Increase During Irradiation	11.05 K	10.98 K
Mercury Volume Increase During Irradiation	0.0392 cm^3	0.0585 cm^3

Each assembly will include a stainless steel filling tube that is attached to the radial wall used to fill the assemblies and to provide the additional space for the expansion of the mercury to prevent the assembly from building pressure during the irradiation. Along with the assemblies above an additional front and back plate of 0.10 cm thick stainless steel (type 316) will be attached. In order to monitor the proton flux via measurement of the $^{27}Al\ (p,x)^{22}Na$ reaction a stack of three thin (10 μm) aluminum foils will be placed in front and in back of the assembly/plates above .

After irradiation the assemblies will be allowed to decay for a minimum of 30 min before remove. After the decay time the dose rate from the assembly is calculated to be less than 20 mRem/hr at 1 m from the assembly.

Gamma spectroscopy analysis of the aluminum foils and the target assemblies with additional front and back plates will be completed post irradiation at LANSCE shortly following irradiation. An additional gamma spectroscopy measurement of the target assemblies will be taken at LANSCE 15 days after irradiation. For the gamma spectroscopy measurements Georgia Tech will ship and use their own equipment.

After additional decay the target assemblies will be shipped to Georgia Tech for additional analysis (30-45 days post irradiation). Additional analysis will be conducted at Georgia Tech and will occur at least 60 days after the irradiation to include the following measurements. 1.) Gamma spectroscopy measurement of the entire target assemblies complete with additional front and back plates. 2.) Gamma spectroscopy measurement of the mercury removed from the assemblies. 3.) Gamma spectroscopy measurements of the additional front and back covers as well as the front and back walls of the target vessel will be taken. The measurements at LANSCE and at Georgia Tech will be used to determine the production cross sections of the selected isotopes. In addition the measurements taken in step 3 at Georgia Tech will be used to determine if any isotopes produced in the target mercury plate out into the stainless steel.

Mercury Handling

In order to limit the handling of mercury at LANSCE, every attempt will be made to pre-fill the target assemblies prior to shipment. However in the event that they cannot be pre-filled the intent will be to use personnel from SNS with specialized training to fill the target assemblies. These personnel will be at LANSCE for another experiment that the SNS target group is proposing in target 2 (blue room) for this current cycle.